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1343431

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(19)

(54) IMPROVEMENTS IN OR RELATING TO SCREENS

(71) We, BBA GROUP LIMITED, of P.O. Box No. 20, Cleckheaton, Yorkshire, A British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to screens which are used to separate and grade various sizes of particles comprising rocks, chemicals, mineral ores or the like which, for convenience, will hereinafter be referred to as "raw material".

Such a screen (which is frequently termed, and will be referred to hereinafter as, a "screen cloth") is provided with an array of apertures of fixed dimensions which extend throughout the thickness of the cloth so that particles of raw material with overall dimensions which are less than that of the apertures are able to pass freely through the screen cloth whilst the larger particles of raw material are retained on the upper surface (hereinafter called the "deck") of the screen cloth. In order to facilitate the passage of the particles of raw material through the apertures, the screen cloth is usually attached to a metal frame which is continually or intermittently vibrated in a plane which may be horizontal or inclined at an angle to the horizontal. By this means it is thus possible to grade a sample of raw material into particles of varying sizes.

One hitherto proposed method of grading raw material has been to use steel or other metal meshes as screen cloths. However, this method suffers from the disadvantage that the metal mesh has a short life due to abrasion by the material being graded and the fatigue of the metal as a result of the vibration. A further disadvantage of metal screen cloths is that screening is frequently made under damp or acid conditions with a consequence that a metal screen cloth is prone to rusting or corrosion; although screen cloths of a non-rusting metal have been proposed these have a working life which is not commensurate with their cost. In an attempt to overcome this problem it has been suggested that the metallic mesh should be surrounded with a surface of rubber or other such composition having high elasticity. There was thus provided a metal screen cloth which was protected against damp conditions and corrosion by acids or alkalis whilst the rubber surface also provided a cushion for the particles passing through the screen. However, it was found that the abrasion resistance of the mesh reinforced rubber screen cloth was low and, when the screen cloth was vibrated, the wire mesh cut and chafed the rubber and this led to early failure of the screen cloth.

Screen cloths composed wholly of rubber have also been proposed in which the apertures are cut or punched in a plain rubber sheet but this leads to a very high wastage of rubber and is consequently expensive. Apertures punched in rubber sheets tend to have convex shaped walls as it is difficult to punch an aperture in such a sheet and ensure that the cross-sectional area of the aperture remains consistant throughout the thickness of the sheet. Particles of raw material being screened by a rubber screen cloth with its apertures so formed often become trapped between the convex shaped walls in the diminishing area of an aperture and this highly undesirable characteristic is known as "aperture blinding". In addition to being costly to manufacture, rubber screen cloths suffer from several disadvantages during use. For example, it has been found that the mechanical rigidity of a rubber screen cloth, usually, is insufficient to support a heavy load of raw material.

It is an object of the present invention to provide a method of making a screen cloth which alleviates the problems and disadvantages encountered by hitherto proposed screen cloths as outlined above.

According to the present invention there is provided a method of making a polyurethane screen cloth which comprises forming a positive master mould corresponding to the screen cloth; casting a liquid polyurethane into the positive master mould; curing the

polyurethane cast into the positive master mould; removing the cured polyurethane from the positive master mould to provide a polyurethane negative mould part having an array of male part projections which are complementary in size, shape and disposition to apertures to be defined in the screen cloth; casting a liquid polyurethane around the array of male part projections of the negative mould part while the latter is substantially horizontally disposed with the male part projections upstanding thereon; curing the polyurethane cast around the male part projections, and removing the cured cast screen cloth from the negative mould part.

The polyurethane compound employed in the present invention may be any combination of one or more polyisocyanates with one or more active hydrogen containing compounds, which are compounded as liquids (with heating if necessary) and give elastomeric products when cured. It is to be understood that the polyisocyanate may be a simple polyisocyanate such as 2,4 tolylene diisocyanate, m - phenylene diisocyanate, 1,5 naphthalene diisocyanate or triphenyl methane triisocyanate or a prepolymer containing free isocyanate groups. The prepolymers can be formed by reacting an active hydrogen containing compound with molar excess of simple polyisocyanate hereinbefore defined, such as polytetramethylene glycol reacted with 2,4 tolylene diisocyanate in the molecular ratio 1:2. The term active hydrogen refers to hydrogen atoms which display activity according to the Zerewitinoff test as described by Kohler in the Journal of the American Chemical Society 49, 3181 (1927). These hydrogen atoms hence react with isocyanate groupings to give chain extension or cross-linking points: Representative examples of active hydrogen containing compounds include polyethers with terminal hydroxyl groups such as polypropylene glycol, polytetramethylene glycol, polyesters with terminal hydroxyl groups such as polyethylene adipate, polypropylene sebacate, or simple molecules such as 1:4 butanediol, 4-4' methylene - bis - (orthochloroaniline) or trimethylol propane. We have found that the proprietary polyurethane casting materials sold under the registered Trade Marks "Adiprene L 100" and "Adiprene L167" (both made by the DuPont Co.) which are tolylene - diisocyanate - polytetramethylene glycol compounds, when cured by DuPont agent sold under the registered Trade Mark "M.O.C.A." (4-4' methylene - bis - (orthochloroaniline)) are particularly suitable materials for making the screen cloth in accordance with the present invention. Varying proportions of additives such as fillers, pigments, plasticizers, flame retardents and/or stabilizers, as are well known to those skilled in the art of forming polyurethane elastomers, may also be added to the liquid castable polyurethane.

Polyurethanes are high stiffness elastomers and as such are able to support a considerable load of raw material without undue sagging or distortion occurring in screen cloths formed of them.

Furthermore polyurethanes have good resistance to abrasion and cutting which provides a screen cloth having excellent wear characteristics. Since polyurethanes are available in a liquid castable form it is a considerable advantage of the present invention that relatively simple casting techniques may be employed for forming the screen cloth. By adopting such a simple casting technique a wide variety of aperture profiles (that is the aperture shape as seen in section through the thickness of the cloth) may be achieved which would not normally be possible by use of the aforementioned punching techniques.

To construct a screen cloth in accordance with the present invention it is necessary to first form a mould into which the polyurethane can be cast. The mould preferably comprises a substantially horizontal shallow tray or box (hereinafter called a "casting box") whose overall internal dimensions are those of the required screen cloth. The apertures within the screen cloth are produced by forming a spaced and preferably ordered array of male part projections within the casting box which projections are upstanding relative to a substantially horizontal base of the casting box. The male part projections are naturally profiled to be complementary to the dimensions, shapes and disposition of the apertures which are required in the finished screen cloth.

The male part projections in the casting box may be considered as providing a negative mould part for the screen cloth and a positive casting (that is the screen cloth) is formed by pouring a liquid polyurethane onto the negative mould part. The casting box is filled with polyurethane and the casting is then cured either by being allowed to stand at ambient temperature (that is self-curing), or by the application of heat. The moulded screen cloth is then removed from the casting box and at this stage any "flashes" of polyurethane which may have formed around the edges of the cloth are removed by a cleaning and trimming operation. In order to facilitate the easy removal of the screen cloth from the casting box and male parts it may be necessary to coat the male parts and interior of the box with a release agent as, for example, a silicone wax.

When a positive casting (that is the screen cloth) has been obtained it will be appreciated that this positive casting can then be placed into a further casting box (without the male part projections) in order to provide a posi-

tive mould in which further negative mould parts may be formed. This considerably reduces the cost of subsequent casting operations since only one master casting box is required. It is to be realised that the surfaces of the polyurethane negative mould part (and preferably the surfaces of the casting box) which are to contact the liquid polyurethane being cast should be painted with a suitable release agent to prevent the moulded screen cloth from becoming bonded to the polyurethane male part projections.

As an alternative to using a pre-cast polyurethane screen cloth as a positive mould structure on which further polyurethane negative mould parts (that is moulds having the male part projections) can be cast, an independent master positive mould structure may be formed which corresponds to the screen cloth to be cast; similarly to using the pre-cast polyurethane screen cloth as a positive mould, the master positive mould structure may be placed in a casting box and the negative mould is formed by casting a polyurethane over it to produce the male part projections on the negative mould part. The aforementioned independent master positive mould structure may comprise a sheet of plastics material (for example polypropylene) or, a sheet of metal or a wooden board which is suitably machined to correspond to the form of the screen cloth, and in each such case the master positive mould structure may be coated with a suitable release agent to facilitate removal of the negative mould part of the screen cloth which is cast thereon.

The apertures in the deck of the screen cloth may be moulded in any desired shape such as oval, eliptical or regular polygonal but, in general, it is preferred that they are of circular or rectangular section in the plane of the screen cloth. Whilst not being essential, it is convenient if the shape and size of all the apertures in a given screen cloth are the same, and some or all of such apertures may be of constant section throughout the thickness of the cloth. However, it is common in screening operations to find that the effective area of the apertures throughout the thickness of the screen cloth becomes reduced due to the build-up of particles of raw material within the aperture (aperture blinding). We have found that in order to alleviate this problem of blockage it is advisable to vary the cross-sectional area of the aperture throughout the thickness of the screen cloth. We therefore prefer to arrange for the cross-sectional area of an aperture where it emerges in the undersurface of the screen cloth to be greater than the cross-sectional area of the aperture where it opens into the deck of the screen. With this in mind some or all of the apertures in the screen cloth may taper uniformly outwardly throughout the thickness of the cloth from the deck to the undersurface thereof. However it is preferred if some, or all, of the apertures each have a part length through part of the thickness of the cloth which part length extends from the deck of the cloth and is of constant section, and the remaining part lengths of those apertures through the remaining part thickness of the cloth taper outwardly to emerge in the undersurface of the cloth. In one form of construction, each aperture in the screen cloth (as viewed in section through the thickness of the screen cloth) is of frusto-conical shape with its small diameter opening located in the deck. Alternatively, and in a preferred construction, each aperture comprises a part cylindrical portion opening at one end into the deck and at the other end into a part frusto-conical portion, the frusto-conical portion of the aperture being that portion which opens into the undersurface of the screen cloth. We have found that when part cylindrical and part frusto-conical apertures are formed in the screen cloth, blinding is less likely to occur.

When a screen cloth is intended for use under large loadings of raw material, or in other heavy duty applications, it may be necessary to reinforce the cloth with a reinforcing structure such as metal rods, or a lattice of wire or plastics mesh. Such reinforcing structure is preferably embedded within the polyurethane during the casting of the screen cloth (for example by locating the reinforcing structure to run between or adjacent the male part projections in the casting box prior to pouring the polyurethane). By providing a reinforcing structure which consists of, or includes, metal bars, two or more of such bars may conveniently be embedded along the edges of the polyurethane of the screen cloth and used to secure the cloth to a vibrating frame as, for example, by bolting or riveting the cloth through the bars to the frame. This technique has the advantage that the vibratory forces and the weight of raw material being screened may be distributed uniformly along the entire edge of the screen cloth.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying illustrative drawings in which:—

Fig. 1 is a perspective view of a screen cloth made in accordance with the method of the present invention in which, for convenience, all the apertures in the cloth have not been shown;

Fig. 2 is a section of the screen cloth shown in Fig. 1 taken along the line II—II of Fig. 1;

Fig. 3 is a perspective view of a negative mould part having an array of male part projections which are complementary to the apertures provided in the screen cloth of Fig.

1 and in which, for convenience, all the male part projections have not been shown;

Fig. 4 is a section through a casting box in which is located the negative mould part shown in Fig. 3 for casting the screen cloth shown in Fig. 1;

Figs. 5 to 8 each illustrate a section through the thickness of a screen cloth made in accordance with the method of the present invention to show the form of alternative apertures which may be provided in the cloth and include a plan view of that aperture as seen from the undersurface of the cloth, and

Figs. 9 to 11 show portions of a screen cloth made in accordance with the method of the present invention and respectively illustrate the manner in which the apertures may be disposed over the deck of the screen cloth.

The screen cloth 1 shown in Figs. 1 and 2 is of substantially rectangular shape and is made from a liquid castable polyurethane such as that sold by E. I. DuPont de Nemours & Co. under the registered Trade Mark "Adiprene L 100" with curing agent M.O.C.A. (registered Trade Mark) in the ratio 100 to 12.5 parts by weight respectively. This type of polyurethane has been found particularly suitable (when cured) as providing screen cloths possessing high abrasion resistance combined with good load carrying properties. The polyurethane screen cloth is cast to predetermined dimensions, for example, a rectangle of six feet by four feet and of required thickness, to define an array of apertures shown generally at 2. The apertures 2 extend through the thickness of the screen cloth to emerge at one end in the deck 3 and at the other end in the undersurface 4 of the cloth. The apertures 2 are spaced in the cloth at required distances from each other and are disposed in straight and parallel rows (the section in Fig. 2 being taken through one of such rows). The screen cloth shown in Figs. 1 and 2 has cylindrical apertures so that they are of constant circular section throughout the thickness of the cloth and, in a specific construction, such apertures are 25 mm diameter and equally spaced from each other to give a free area in the screen cloth of approximately 50%.

The screen cloth 1 may have a reinforcing structure which comprises an array of metal bars or rods (shown generally at 5 see Fig. 5) which extend lengthwise and widthwise through, and are wholly embedded in, the polyurethane of the screen cloth.

Although the apertures in the cloth shown in Figs. 1 and 2 are of cylindrical shape (as shown in the enlarged section of Fig. 5), alternatively shaped apertures may be provided in the screen cloth as shown in Figs. 6 to 8. In Fig. 6, the aperture 2 is of circular section in the plane of the cloth and has a part length 6 through part of the thickness of the cloth 1 which part length extends from the deck 3 and is of constant section (cylindrical) whilst the remaining part length 7 of the aperture through the remaining part thickness of the cloth 1 is of frusto-conical shape and tapers outwardly from the part length 6 to emerge in the undersurface 4 of the cloth. In a specific example, the frusto-conical part length 7 of the aperture extends for approximately half the thickness of the screen cloth and has an included angle α of approximately 10°. The aperture in Fig. 7 is of square section in the plane of the cloth and is of constant section throughout the thickness of the cloth. The aperture in Fig. 8 is of square section in the plane of the cloth but has a part length 8 through part of the thickness of the cloth 1 which part length 8 extends from the deck 3 and is of constant section whilst the remaining part length 9 of the aperture tapers outwardly from the part length 8 to emerge in the undersurface 4 of the cloth. The aperture of Fig. 8 is, in a specific example, formed so that the tapered part length 9 extends for approximately half the thickness of the screen cloth 1 whilst the opposed side walls of the part length 9 are inclined at an included angle α of approximately 10°.

As aforementioned, the apertures 2 in the screen cloth 1 are conveniently disposed in spaced, straight and parallel rows as shown at A, B and C in Figs. 9 to 11 respectively. The rows A, B and C extend across the width of the screen cloth and the apertures in each of such rows may be disposed to form straight and parallel rows of apertures extending lengthwise of the screen cloth (as shown in Fig. 10). However, with the apertures disposed in lengthwise and widthwise rows as shown in Fig. 10, it is possible that raw material being screened and moving over the deck 3 of the screen cloth in the direction of arrow X will pass along the continuous paths formed between adjacent apertures and thereby avoid being graded as to particle size. It is therefore preferred if the apertures in two adjacent rows (A and E, and/or B and C) are offset in a widthwise direction with respect to each other so that a system of apertures is formed which, when viewed in the direction of arrow X, presents an apparently and substantially unspaced (or closed) array of apertures (See Figs. 9 and 11). Consequently when raw material moves over the decks 3 of the screen cloths in Figs. 9 and 11 and in the direction of arrow X, such material should be screened for particle size by at least one aperture 2. With this in mind, and in a preferred arrangement for the disposition of the apertures 2 as shown in Figs. 9 and 11, the apertures in two adjacent rows A and B (and B and C) are so disposed that the centres of areas in the deck 3 of two adjacent apertures in row A (or row C) and the centre of area in the deck of an

aperture in row B are situated at the apices of notional equilateral triangles (indicated by the broken lines 10 in Figs. 9 and 11) in the deck.

In making a screen cloth as above described with reference to Figs. 1, 2 and 5 to 11, a negative mould part 11 (see Figs. 3 and 4) of the screen cloth is first provided which has an array of male part projections 12 complementary in size, shape and disposition to the apertures to be defined in the screen cloth. Such a negative mould part is located in a horizontally disposed casting box in the form of a rectangular shallow tray 13 having a base 14 and side plates 14a (see Fig. 4). The reinforcing metal bars or rods 5 (when provided) may be positioned to extend widthwise and lengthwise between the male part projections 12 and such bars or rods are conveniently positioned (for example by resting on shoulders in the side plates 14a) approximately half way down the length of the male part projections 12 which are perpendicularly upstanding relative to the base 14 of the casting box. A liquid polyurethane is now poured around the array of sale part projections 12 (and reinforcing structure 5 if provided) to a level consistent with the top of the male part projections. The cast polyurethane is now cured (either by self curing or accelerated curing under heat) and the moulded screen cloth removed from the male part projections.

The negative mould part 11 of the screen cloth is constructed as an integral unit by casting from a positive master mould which corresponds to the screen cloth which is to be formed. Such a positive master mould may be made by machining a sheet of metal, wood or plastics, and the negative mould part 11 is formed by casting a liquid polyurethane over the positive master mould (which is coated with a release agent), curing such cast polyurethane and removing the cured polyurethane from the master mould to expose the male part projections formed by the liquid polyurethane entering the apertures in the positive master mould.

In a preferred method of constructing a negative mould part similar to that shown in Fig. 3 (but which is modified to have male part projections which are adapted to form apertures in the cast screen cloth similar to those shown in Fig. 6) a rectangular sheet of polypropylene approximately six feet by four feet and of the same thickness as the screen cloth which is to be cast is drilled through its thickness with holes of the same size and spacing as the aperture parts 6 in the screen cloth which is to cast (for example 25 mm diameter round holes which are equally spaced from each other to give a free area in the polypropylene sheet of approximately 50%). These holes are then countersunk to correspond with the aperture parts 7 and to a depth of approximately half the thickness of the polypropylene sheet at an included angle (equal to angle α) of approximately 10°. A backing sheet of polypropylene approximately 3 mm thick is then secured, conveniently by screws, in face-to-face contact with the drilled sheet of polypropylene so that the larger diameter end of the holes are positioned away from the backing sheet. The combined polypropylene sheets are then placed on a flat horizontal surface with the open ends of the holes disposed upwardly. A framework of metal plates or bars is now assembled on the drilled sheet of polypropylene to form a rectangular enclosure above the upper surface of the drilled polypropylene sheet. A liquid polyurethane comprising the aforementioned mix of the materials "Adiprene L 100" (registered Trade Mark) and "M.O.C.A." (registered Trade Mark) is now poured into the rectangular enclosure from which it enters the drilled holes and such liquid polyurethane is poured until a depth of approximately 10 mm above the upper surface of the drilled polypropylene sheet is attained in the enclosure. Prior to pouring the liquid polyurethane, the framework is treated with a silicon release agent to ensure that it may be dismantled without difficulty after the poured polyurethane has been cured.

The aforementioned framework may be adjustable to enclose a variable, but predetermined, area on the upper surface of the drilled polypropylene sheet. If necessary, specific drilled holes in the polypropylene sheet within the enclosed area of the framework may be obturated on the upper surface of the drilled sheet by masking tape or the like so that no male part projections on the cast polyurethane negative mould part 11 are provided at positions corresponding to such masked area; consequently a full thickness of polyurethane on the finally cast screen cloth will be obtained at positions which correspond to such masked holes. For example, a full thickness of polyurethane in the screen cloth may be required adjacent the edges of the cloth to facilitate its attachment to a vibrating frame.

After the polyurethane has been poured into the enclosure formed by the framework, the assembly is heated to cure the polyurethane. The framework is then dismantled, the backing sheet of polypropylene removed from the drilled sheet of polypropylene and any "flashes" of the cast polyurethane removed. The polyurethane negative mould part 11 is now removed from the drilled polypropylene sheet and is ready for use to make a polyurethane screen cloth as described below.

The polyurethane negative mould part 11 is treated with a silicone release agent and placed on a flat horizontal table or base 14

so that the male part projections 12 stand upwardly from the base (see Fig. 4). Metal side plates 14a which have been similarly treated with a release agent are now clamped on both sides of the width and length of the negative mould part to abut firmly against its margins to form the casting box 13. The side plates 14a of the casting box are adapted to carry the metal reinforcing bars or rods 5 so that they can be moulded into the screen cloth and such reinforcing bars or rods are shot blasted, de-greased (for example with the material sold under the trade name "Trichlor") and treated with a bonding agent (for example the material sold under the registered Trade Mark "Thixon XAB—1153").

The liquid polyurethane is now poured into the casting box which is subsequently heated to cure the polyurethane. The metal side plates of the casting box are now dismantled and the polyurethane screen cloth 1 removed from the polyurethane negative mould part 11 and "flashes" of polyurethane which may have been formed on the screen cloth during casting are removed by a trimming and cleaning operation.

As an alternative to heating the combined casting box and cast polyurethane screen cloth, the polyurethane cast into the casting box may be allowed to cure at ambient temperature and thereafter the cured screen cloth removed from the casting box and further cured by heating in an oven.

WHAT WE CLAIM IS:—

1. A method of making a polyurethane screen cloth which comprises forming a positive master mould corresponding to the screen cloth; casting a liquid polyurethane into the positive master mould; curing the polyurethane cast into the positive master mould; removing the cured polyurethane from the positive master mould to provide a polyurethane negative mould part having an array of male part projections which are complementary in size, shape and disposition to apertures to be defined in the screen cloth; casting a liquid polyurethane around the array of male part projections of the negative mould part while the latter is substantially horizontally disposed with the male part projections upstanding thereon; curing the polyurethane cast around the male part projections, and removing the cured cast screen cloth from the negative mould part.

2. A method as claimed in claim 1 which comprises coating the male part projections with a release agent prior to casting the polyurethane to facilitate removal of the cast screen cloth from the polyurethane negative mould part after curing.

3. A method as claimed in either claim 1 or claim 2 which comprises locating a reinforcing structure adjacent to the male part projections prior to casting the polyurethane so that said reinforcing structure is embedded within the polyurethane of the cast and cured screen cloth.

4. A method as claimed in any one of the preceding claims which comprises forming the positive master mould in wood, metal or plastics material by machining operations.

5. A method as claimed in claim 4 which comprises forming the positive master mould from a sheet of polypropylene.

6. A method as claimed in any one of the preceding claims which comprises coating the positive master mould of the screen cloth with a release agent over the surface thereof which will contact the polyurethane which is to be cast into the positive master mould to facilitate removal of the cast polyurethane negative mould part from the positive master mould.

7. A method of making a polyurethane screen cloth as claimed in claim 1 and substantially as herein described.

8. A polyurethane screen cloth when made by the method as claimed in any one of the preceding claims.

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1343431 COMPLETE SPECIFICATION

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Sheet 1

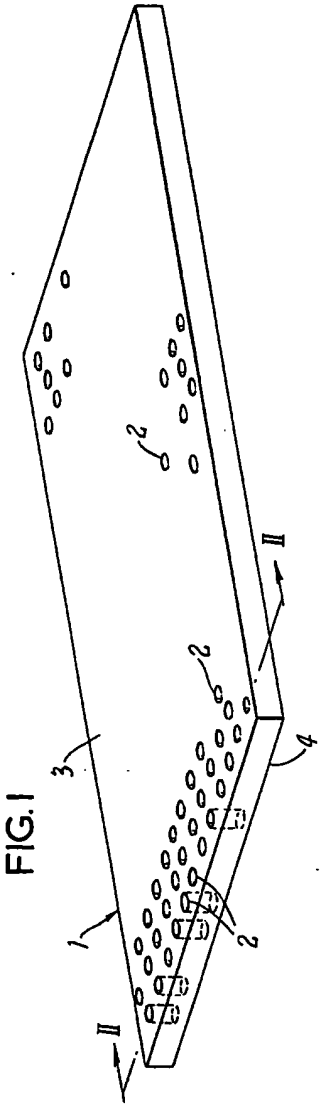

FIG.1

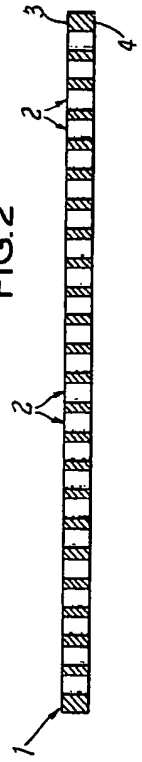

FIG.2

1343431 COMPLETE SPECIFICATION
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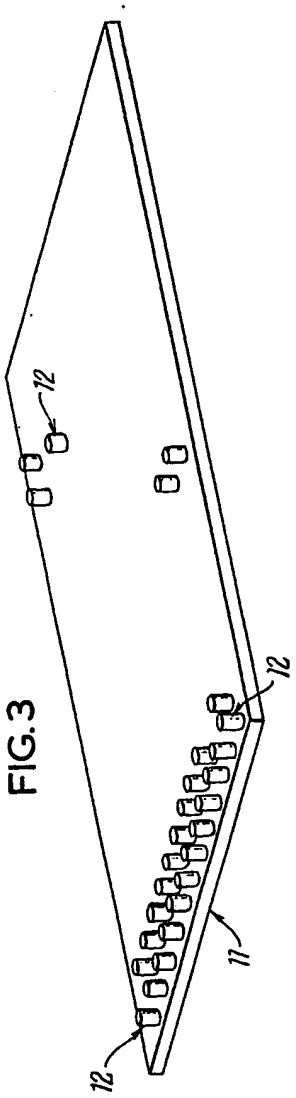

FIG.3

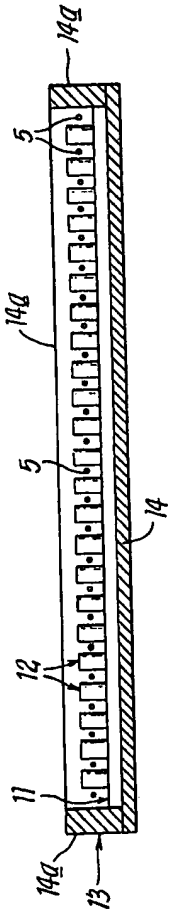

FIG.4

1343431 COMPLETE SPECIFICATION
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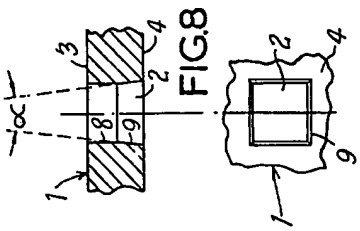

FIG.8

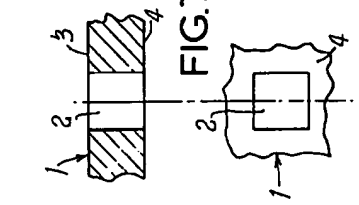

FIG.7

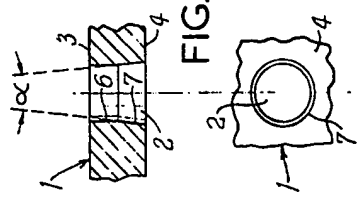

FIG.6

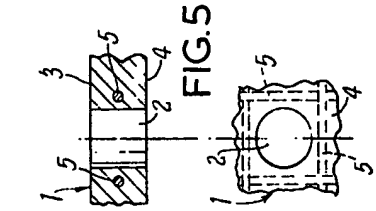

FIG.5

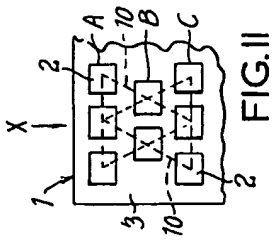

FIG.11

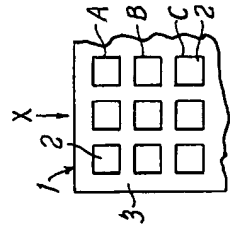

FIG.10

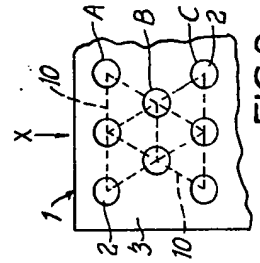

FIG.9